

MADE IN SPACE

A small, detailed illustration of a space station or satellite in orbit, positioned to the right of the word 'MADE'.

Additive Manufacturing In Space

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Chief Engineer, Made In Space, Inc.

- Founded in 2010
- HQ at NASA Ames Research Park.
- 24 employees/advisors
- Expert team in both space systems and advanced manufacturing
- Vision Extends Beyond ISS Operations
- Large Internal R&D focus.
- Extensive IP
- Over 100 years of total space mission experience
- Only Space Manufacturers
- >Core Team has 30.5 days total “zero” G time





- Logistics of Space Travel
Currently is Slow and expensive.
- Everything that has Gone or is
Going to Space has been
Overdesigned
 - Primarily for Launch
 - <10 Minutes of Mission
- Also Must Fit in Launch Fairing or
Capsule
- Requires Large Testing Plan
- Inefficient Overall
- Plays Huge Roll in Colonization



MADE IN SPACE

Launch Logistics



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Launch Logistics



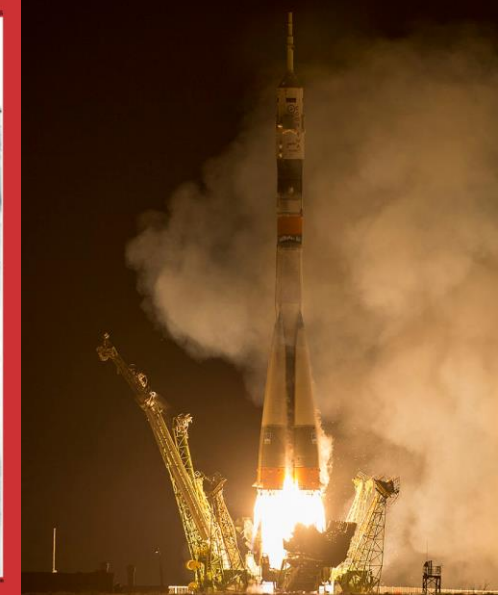
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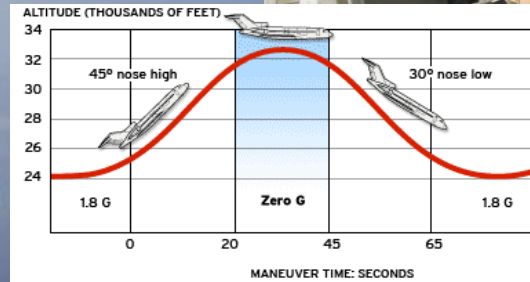
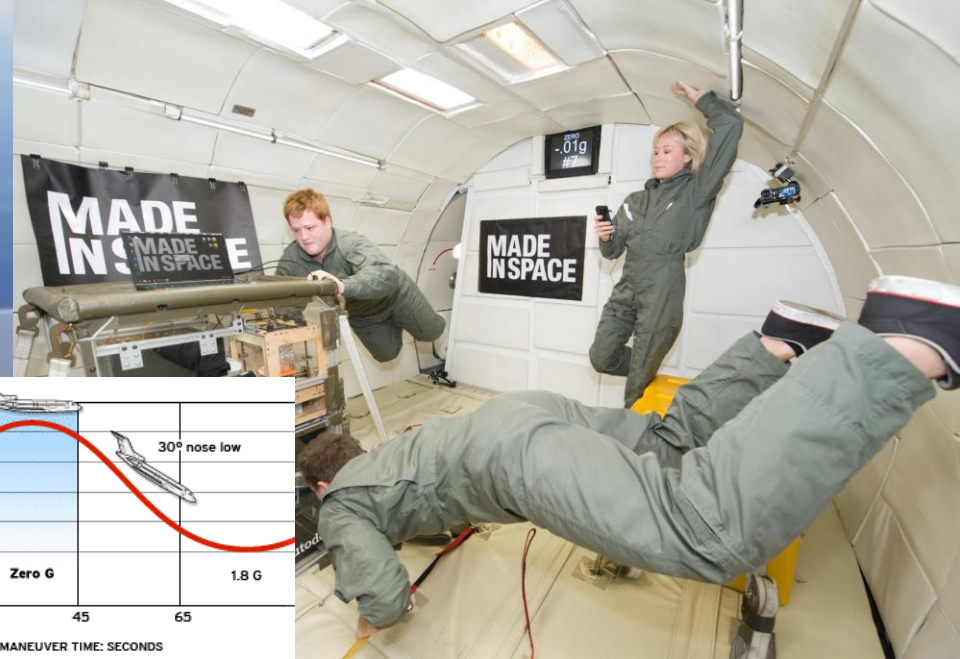
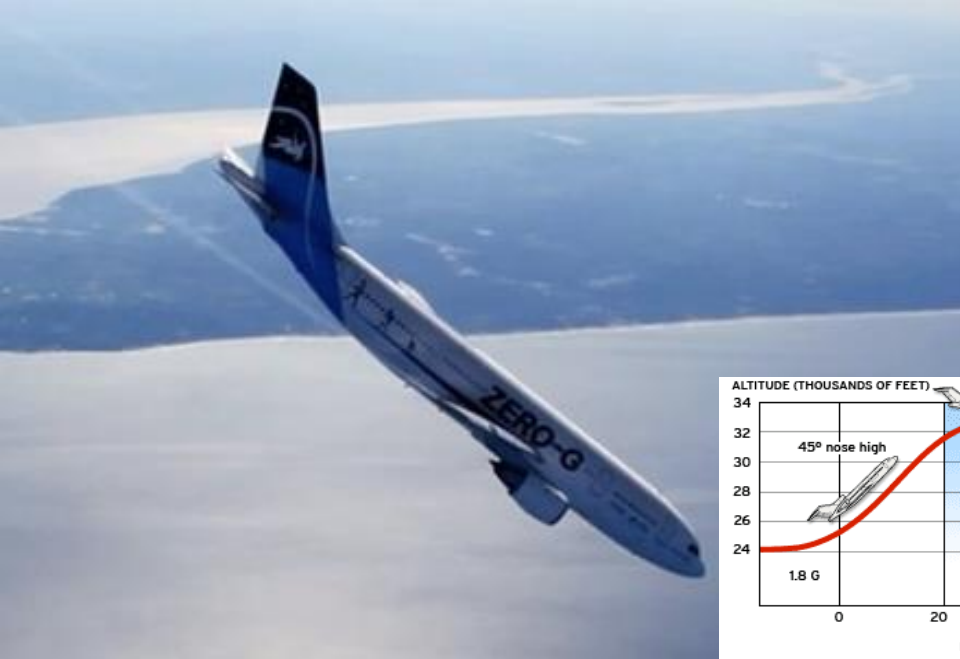
Launch Logistics



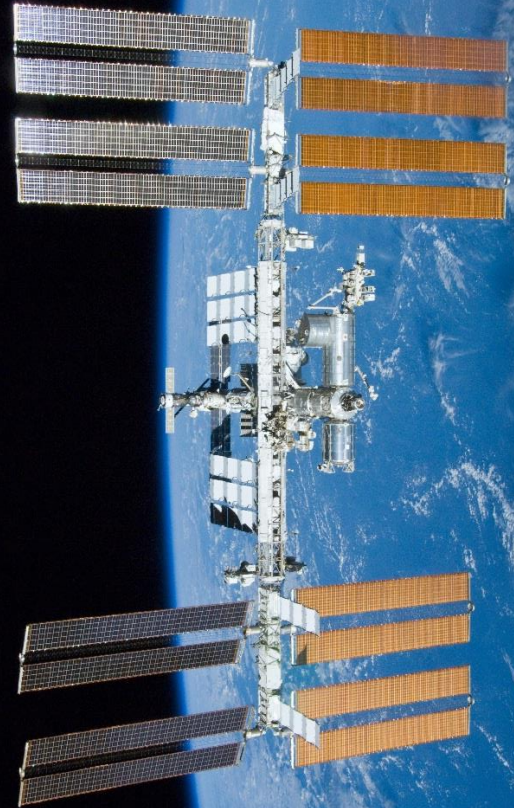
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Launch Logistics



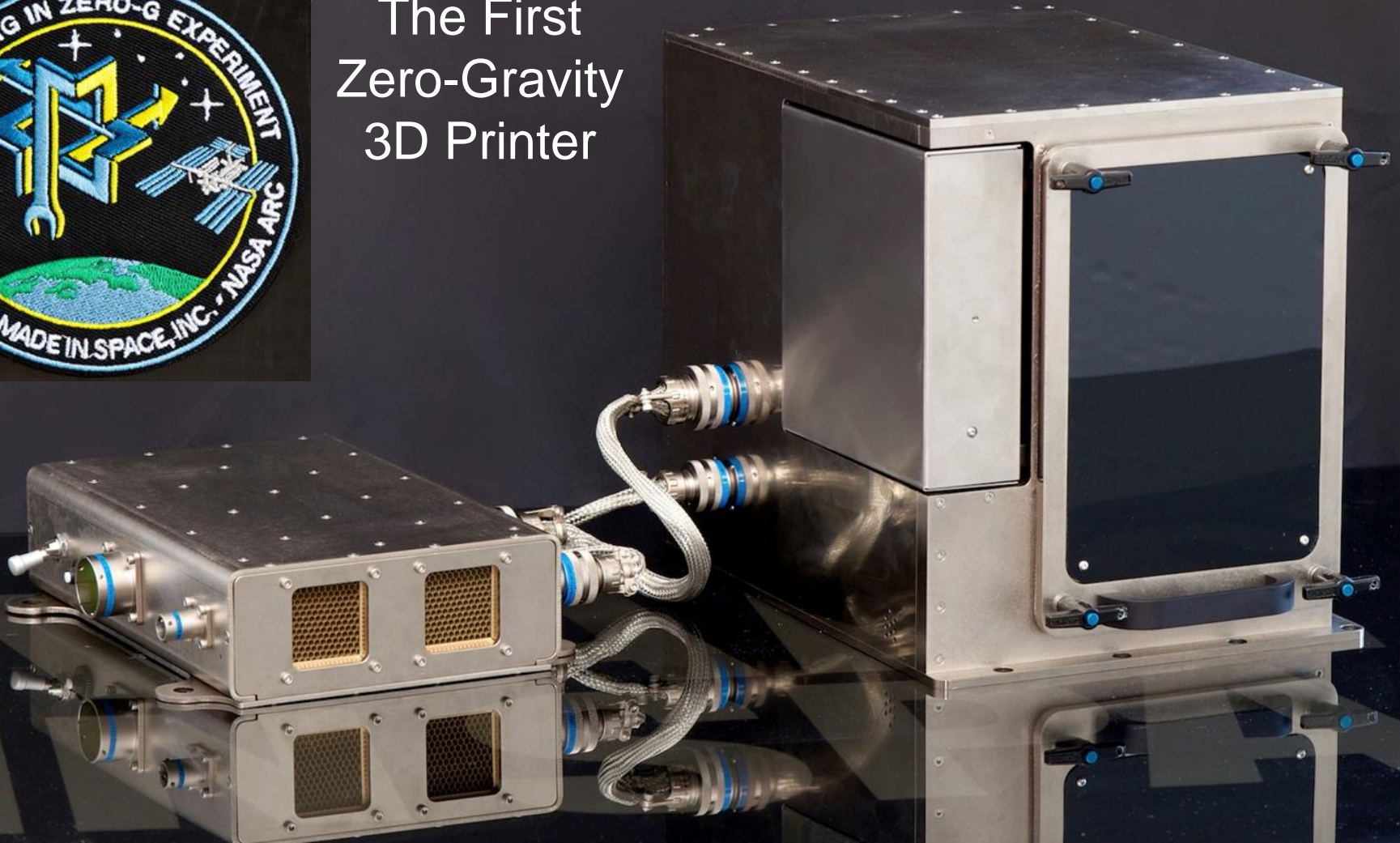


- December 2011- Awarded Phase I SBIR for Additive Manufacturing Facility
 - Developed AMF Concept Further
- February 2013- Awarded Phase II SBIR for Additive Manufacturing Facility
- February 2013- Awarded Phase III Contract for 3D Printing in Zero G Tech Demo
- March 2014- Delivery of Hardware
- Summer 2014- Launch
- November 24, 2014- First Off-Earth Print
- Fall 2015- Additive Manufacturing Facility Launch
- Shortly After- Open for On-Orbit Business





The First Zero-Gravity 3D Printer





9/21/2014

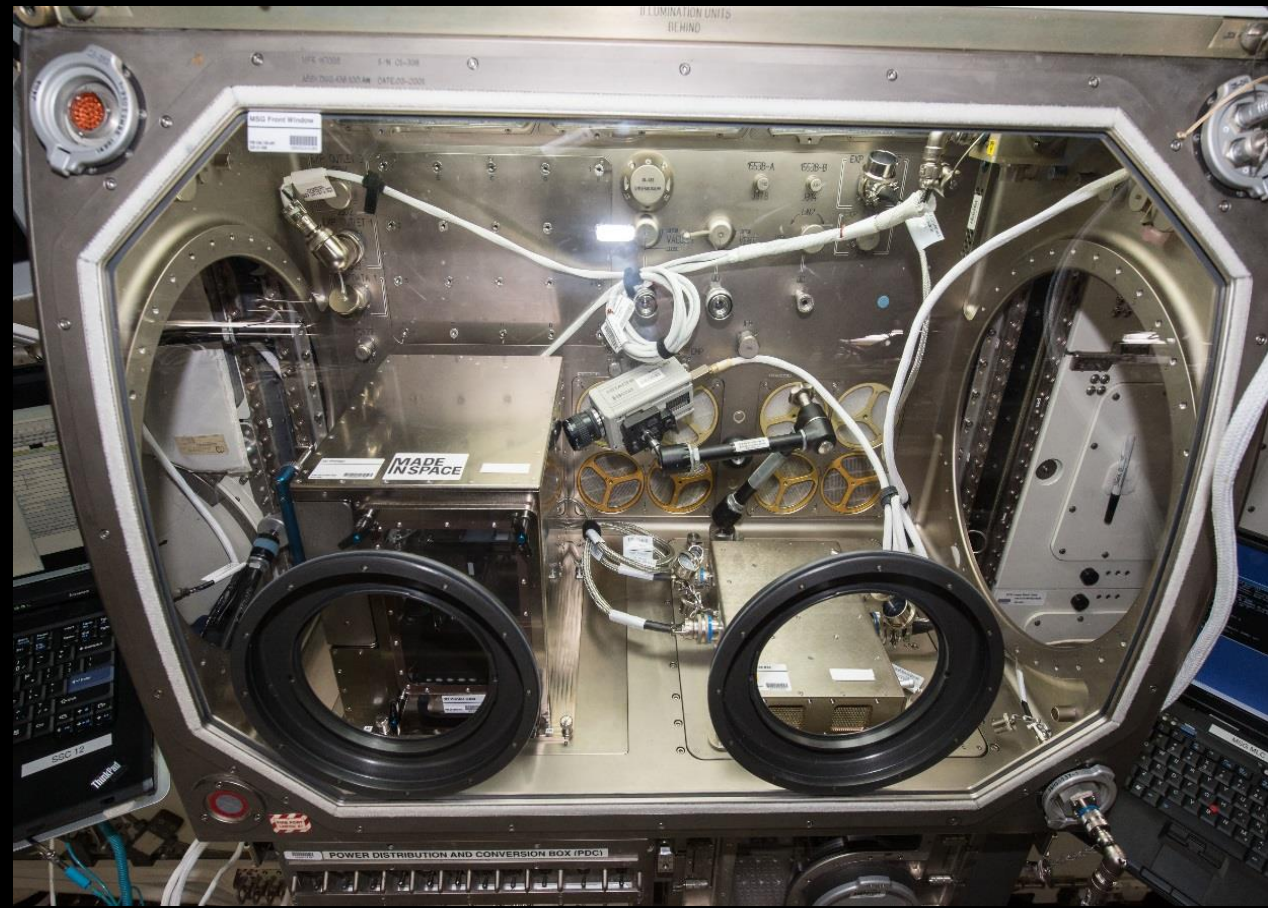
CREDIT: SPACEX







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3D PRINTING IN ZERO-GRAVITY TECHNOLOGY DEMONSTRATION

AREAS OF DISCOVERY

- MICROGRAVITY
- MATERIALS
- FUNCTIONAL TOOLS

CALIBRATION COUPON



PART NAME:
Functional Checkout & Calibration Coupon
DIMENSIONS (INCHES):
1.18 X 1.18 Y 0.18 Z
PRINT DURATION (MINUTES):
18
DESCRIPTION:
Used to test calibration of relationship between extruder and print plate.
PRINT DATES:
11/17/14, 11/20/14, 12/2/14, 12/8/14, 12/8/14

COLUMN



PART NAME:
Layer Quality Test Specimen
DIMENSIONS (INCHES):
0.39 X 0.39 Y 1.18 Z
PRINT DURATION (MINUTES):
45
DESCRIPTION:
Used to assess the layer quality and tolerances for comparison to ground controls.
PRINT DATE:
12/2/14

COMPRESSION TEST



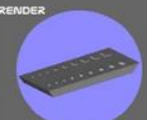
PART NAME:
Compression Test Specimen
DIMENSIONS (INCHES):
0.50 Diameter, 1.00 Z
PRINT DURATION (MINUTES):
45
DESCRIPTION:
Used to assess compressive strength for comparison to ground controls.
PRINT DATES:
12/3/14, 12/5/14, 12/6/14

HOLE RESOLUTION



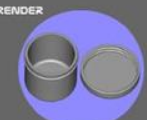
PART NAME:
Performance Negative Range Test Specimen
DIMENSIONS (INCHES):
2.95 X 0.79 Y 0.17 Z
PRINT DURATION (MINUTES):
88
DESCRIPTION:
Used to test geometric accuracy and tolerances for comparison to ground controls.
PRINT DATE:
12/4/14

FEATURE RESOLUTION



PART NAME:
Performance Positive Range Test Specimen
DIMENSIONS (INCHES):
02.41 X 0.79 Y 0.20 Z
PRINT DURATION (MINUTES):
45
DESCRIPTION:
Used to test geometric accuracy and tolerances for comparison to ground controls.
PRINT DATE:
12/5/14

SAMPLE CONTAINER



PART NAME:
Sample Container
DIMENSIONS (INCHES):
Diameter 1.81 - 1.57, 1.29 Z
PRINT DURATION (MINUTES):
109
DESCRIPTION:
Example of a two-piece water-tight sample container providing 1 level of containment.
PRINT DATE:
12/8/14

OVERHANG TEST



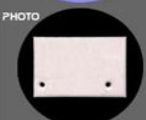
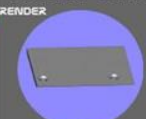
PART NAME:
Microgravity Structure Test Specimen
DIMENSIONS (INCHES):
0.37 X 0.67 Y 0.20 Z
PRINT DURATION (MINUTES):
36
DESCRIPTION:
This is a test of a part that would be difficult, if not impossible, to successfully 3D print due to gravitational effects.
PRINT DATE:
12/9/14

TIMELINE (not to scale)

NOV. 12, 2014
The Zero-Gravity Printer was unpacked from its launch packaging and installed into the Microgravity Science Glovebox.

SEPT. 21, 2014
The Zero-Gravity Printer launched to the International Space Station as part of the SpaceX cargo resupply servicing mission 4 (CRS-4).

PRINTER FACEPLATE



PART NAME:
Side Plate of 3D Printer Extruder Head Casing
DIMENSIONS (INCHES):
2.32 X 1.81 Y 0.20 Z
PRINT DURATION (MINUTES):
74
DESCRIPTION:
This is a replacement part for the 3D printer itself. It is a side plate of the extruder head casing.
PRINT DATE:
11/24/14

TENSILE TEST



PART NAME:
45°/45° Flexural Test Specimen
DIMENSIONS (INCHES):
4.47 X 0.26 - 0.75 Y 0.16 Z
PRINT DURATION (MINUTES):
70
DESCRIPTION:
Used to assess mechanical characteristics for comparison to ground controls.
PRINT DATES:
12/2/14, 12/8/14 (twice), 12/8/14

FLEX TEST



PART NAME:
45°/45° Flexural Test Specimen
DIMENSIONS (INCHES):
3.47 X 0.39 Y 0.16 Z
PRINT DURATION (MINUTES):
68
DESCRIPTION:
Used to assess stiffness properties for comparison to ground controls.
PRINT DATES:
12/3/14, 12/6/14, 12/7/14

TORQUE TEST



PART NAME:
Torque Tool Coupon
DIMENSIONS (INCHES):
1.18 Diameter, 0.984 Z
PRINT DURATION (MINUTES):
165
DESCRIPTION:
Used to test torque strength for comparison to ground controls.
PRINT DATE:
12/4/14

CROWFOOT



PART NAME:
Crowfoot coupon
DIMENSIONS (INCHES):
1.85 X 1.57 Y 0.512 Z
PRINT DURATION (MINUTES):
95
DESCRIPTION:
Used to test structural strength for comparison to ground controls.
PRINT DATE:
12/4/14

CUBESAT CLIP



PART NAME:
Structural clip component
DIMENSIONS (INCHES):
1.6 X 0.827 Y 0.254 Z
PRINT DURATION (MINUTES):
27
DESCRIPTION:
This is a structural connector/spacer that can be utilized to assemble avionics/electronics boards on-orbit.
PRINT DATE:
12/9/14

RATCHET



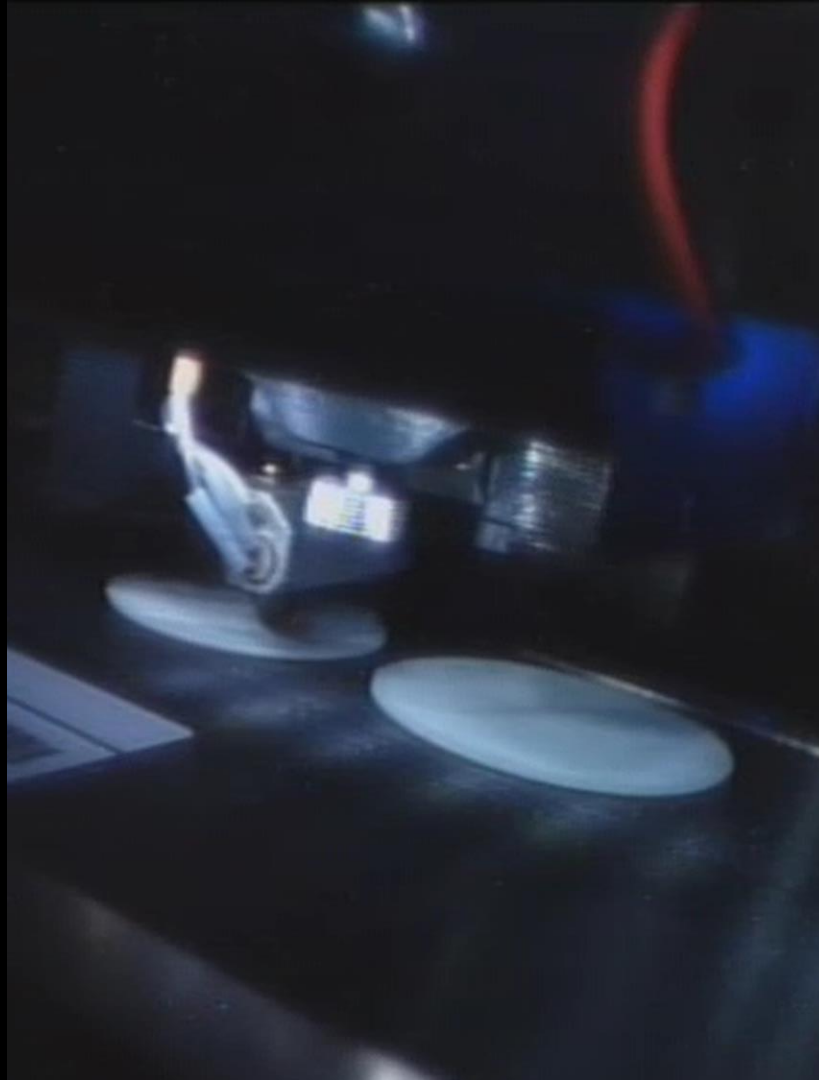
PART NAME:
Ratchet
DIMENSIONS (INCHES):
4.47 X 1.30 Y 1.02 Z
PRINT DURATION (MINUTES):
238
DESCRIPTION:
This part was the only part not pre-loaded on the printer. It shows how a part can be designed and manufactured in space on demand.
PRINT DATE:
12/15/14

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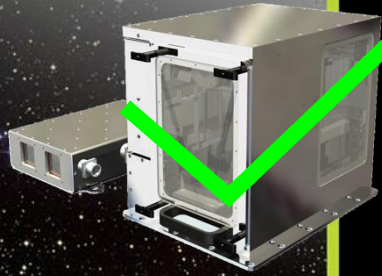






MADE IN SPACE

Made in Space has the proven ability to deliver powerful solutions for NASA.



5 Main Technological Problems:

1. Toxic Gasses
2. Fluctuating Forces
3. Unreliable Prints
4. Complex Interface
5. Safety Requirements

Environmental Control Unit
Gravity Independence
Mission Critical Engineering
Remote Operations Design
Strict NASA Requirements

**MADE
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Additive Manufacturing Facility (AMF)

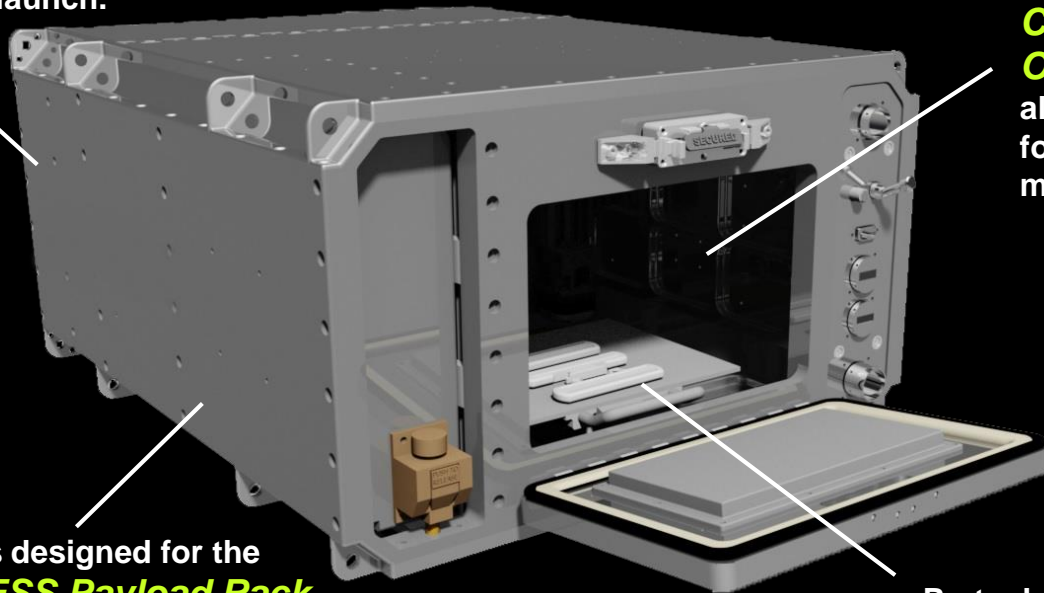
The Permanent Space 3D Printer

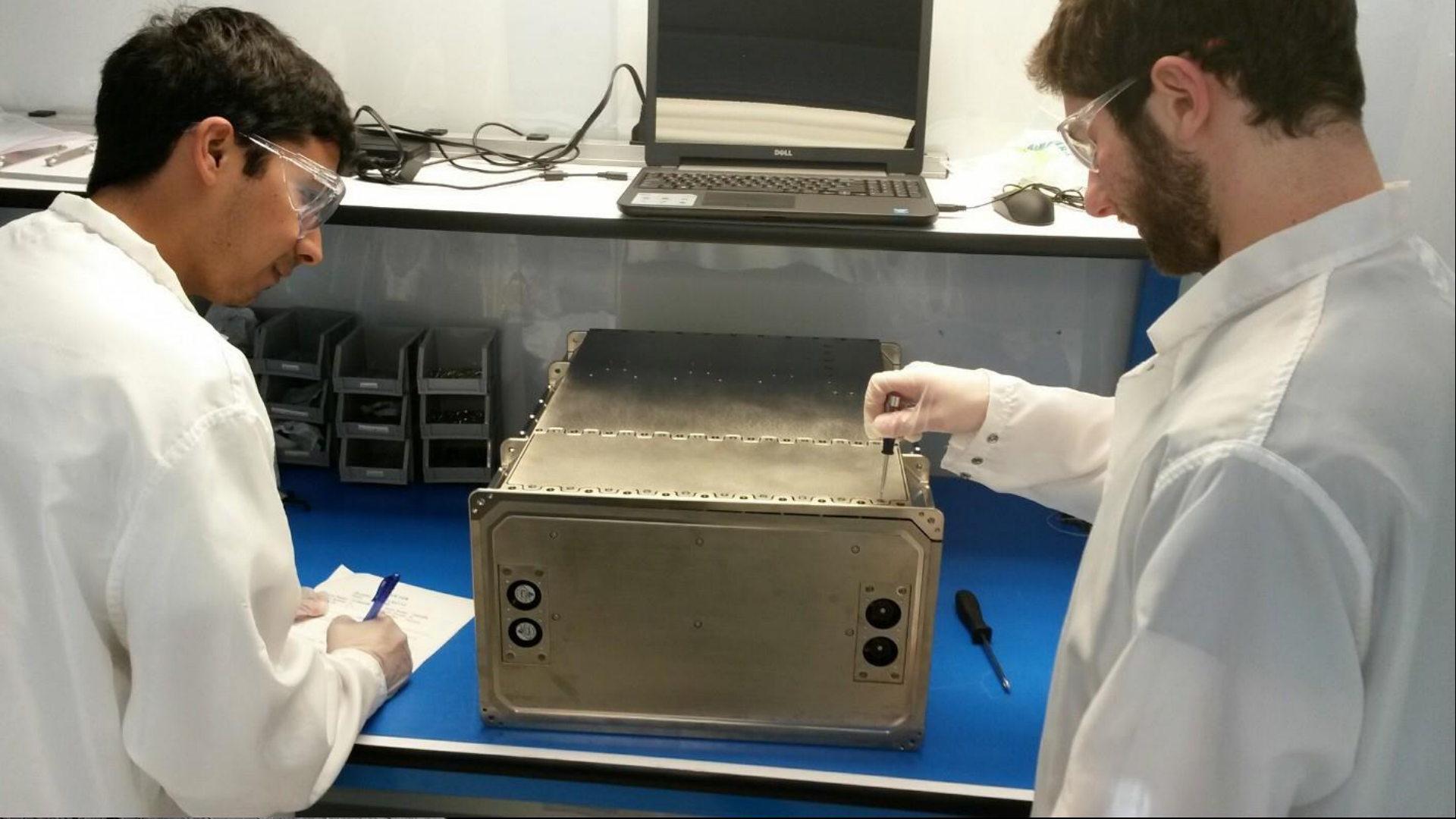
Entire device can
withstand **9 Gs** of
force from launch.

Remote
Calibration and
Operation
allows operators to
focus on the
mission.

Chassis designed for the
EXPRESS Payload Rack

Parts designed using
**Generative Design
Software**





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Thank You

Any questions?

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